Improved treatment

Background of the invention

Glaucoma is generally described as a group of ocular conditions, which involve progressive optic nerve damages, and the loss of visual functions. The pathogenesis of the optical nerve damage remains unclear, but it is widely accepted that a chronic elevation of the intraocular pressure (IOP) is an important factor in glaucoma damage development. The generation of ocular hypertension is associated with an impaired circulation of aqueous humor in the eye which in many cases is the result of an imbalance between the formation of aqueous humor and impaired outflow mechanisms through the trabecular meshwork and Schlemm's canal in the anterior chamber. Conventionally, glaucoma is diagnosed if two of the three criteria among elevated IOP, optical nerve head damage and visual field loss are found in the same of eye a patient. Nevertheless, it is clinically established to prescribe a therapy to individuals, which are exposed to chronic IOP elevation in order to minimize the risk that they acquire irreparable visual damages associated with diagnosed glaucoma. The most widespread IOP-reducer has been the beta-adrenergic agent timolol, which is exerting its effect by reducing the production of aqueous humor and thereby contribute to alleviate the impaired turn-over of aqueous humor of the eye. Recent clinical developments in ophthalmology in terms of glaucoma therapy have established the prostaglandin $F_{2\alpha}$ derivative latanoprost (marketed as Xalatan® by Pharmacia Corp.) as a potent and useful $F_{2\alpha}$ intraocular pressure reducer with few side effects. Since the IOP reducing effect of prostaglandin $F_{2\alpha}$ derivatives including latanoprost has been attributed to their capacity of increasing the uveoscleral outflow of aqueous humor, it has been suggested to combine it with other known IOP-reducing agents exerting their effect through a different mechanism in order to obtain an additive effect. For this reason, combination therapy with beta-adrenergic agonists was early suggested, see European Patent No. 0286903 and US Patents Nos. 5,405,846 and 5,166,175. For example, P Hoyng et al in Survey Ophthalmol. 1997, 41(Suppl. 2), S93 disclose studies made on latanoprost and timolol that demonstrates an additive IOP-reducing effect in patients suffering from an elevated IOP and having an insufficient response to timolol alone. There are several studies directed to investigate the IOP reducing effects from adjunctive therapy of the beta-adrenergic agonist timolol and latanoprost, which suggest that the combination results in a more pronounced hypotensive effect than can be achieved from any of the two drugs alone, see N Pfieffer in IOVS 2000, 41(4), S754; B Sjöquist et al in IOVS 2000, 41(4), S572; LI Larsson in IOVS 2000, 41(4), S280; P Hyong et al in Drugs 2000, 59(3), 411-434; WC Stewart et al in J Ocul Pharmacol Ther, 2000, 16(3), 251-259; K Iishi et al in Jpn J Ophthalmol, 2000, 44(3), 227-

234; PT Hung et al in Am J Ophthalmol, 1999, 128(6), 692-696; PG Watson in Drugs Today, 1999, 35(6), 449-459; C Linden et al in Drugs Aging, 1999, 14(5), 387-398; L Martin in Acta Ophthalmol Scand, 1999, 77(3), 336-339; TW Heijkal et al in Seminars in Ophthalmology, 1998, 14(3), 114-123; M Diestelhorst et al in Graefe's Arch Clin Exp Ophthalmol, 1998, 236(8), 577-581 and A Alm et al in British J Ophthalmol, 1995, 79(1), 12-6. Furthermore, there are several non-prostaglandin containing fixed combinations available for the treatment of glaucoma based on a beta-adrenergic antagonist and a complementary agent with ocular hypotensive effect. Normoglaucon® contains 0.1% metipranolol and 2% pilocarpine. TP-2® or Timpilo-2® contains 0.5% timolol and 2% pilocarpine. Cosopt® contains 0.5% timolol and 2% dorzolamide.

Given that the course of development of glaucoma is unpredictable with a pathogenesis largely varying among individuals, frequently with unnoticeable symptoms and signs, certain patients may have reached an advanced stage of the disease with visual field loss as a result of optical nerve damage, even before they are examined by medical expertise. For this type of patients, it is necessary to institute a radical IOP-reducing treatment. However, conventional IOP-reducers frequently are insufficient to reach suitable results and surgical intervention may be necessary to restore the turn-over of aqueous humor by improving its outflow. Although treatments with combination of IOP-reducing agents which affect the IOP-reduction according to different mechanisms have been suggested to generate additive effects beyond each individual agent, there are so far no indications that any combination therapy would have an especial efficacy for patients suffering from advanced glaucoma. It would therefor be desirable to provide for a therapeutic treatment that was especially efficient in reaching such patients who are suffering from these advanced stages of glaucoma who are at serious risk to acquire further loss of vision to an extent that would compromise their quality of life.

Description of invention

It is an object of the present invention to provide for a therapy according to which particular high-risk glaucoma patients can be treated with greater efficacy.

It is another object of the present invention to provide for a therapy for patients with a particular risk factor of acquiring advanced glaucoma can be treated with higher efficacy.

It is a particular object of the present invention to employ a combination of IOP-reducing agents for simultaneous administration and thereby obtain an improved IOP-reducing efficacy in severe glaucoma patients and individuals having an especial need of a high IOP reduction.

The present invention resides in the finding that a therapy of two or more agents with capacity of reducing the intraocular pressure has an improved efficacy to treat advanced glaucoma in such patients who suffer from detectable vision related impairments, when said agents are administered simultaneously. In the inventive context, simultaneous administration means that the agents are delivered to the eye substantially at the same time, for example subsequently immediately after each other, or that they are co-administered as a mixture. Dependent on the characteristics of the agents they can be pre-mixed in a ready-made solution, or for stability reasons separately stored and mixed, just prior to the administration. There are many devices available to skilled practitioners to prepare a solution *in-situ* and these are not described in any detail herein as they not are a part of the present invention. It is preferred that the combination is a mixture of agents that can be applied to the surface of the eye in the form of a topical ophthalmic preparation delivered in drop form or delivered in the form of a directed stream from a pressurized ophthalmic dispenser.

It has been surprisingly found that the IOP reducing capacity arrived from a combination treatment in such patients significantly exceeds IOP reduction in patients exposed to an IOP increase, who thereby are at risk of obtaining visual damages, but not yet having acquired such advanced stages of the ailment. The inventive method will be particularly useful for the mentioned patients and also for individuals in particular need of a high reduction of IOP due to the exposure of certain risk factors which can be considered to aggravate or accelerate the visual complications arriving from exposure to ocular hypertension. Such individuals include those who belong to family with a history of glaucoma cases and individuals suffering from conditions which may trigger ischemic complications in the region of the optical nerve head. The skilled practitioner will be able to sort out individuals who would be extra susceptible to acquire damages from elevated IOP and thereby will be elected to undergo a combination therapy.

In the context of the present invention advanced glaucoma or severe glaucoma shall be defined as a condition where an individual has acquired an optical nerve damage, i.e. abnormalities of the optical nerve head and defects of the visual field. Both these damages can be detected by standard methods available to ophthalmologists. The presence of an optical nerve damage can be objectively measured for example by laser scanning tomography to measure the nerve fiber thickness, see LM Zangwill et al. Optometry and Vision Science, 1999, 76(8), pp. 526-36 or the similar methods to objectively estimate the loss of tissue. Visual field loss can be measured by conventional methods employed by ophthalmologists.

In further context of the present invention, a combination of IOP reducers is defined as at least two different agents with IOP reducing capacity acting according to different mechanisms in

their to provide the reduction when they are concomitantly administered. For example, such differences in mechanistic onset of the IOP-reduction could include stimulation (affinity to) of different receptors in the eye, however, not necessary located at different sites of the eye. Accordingly, different prostaglandin derivatives with different prostaglandin receptor profiles can be used, such as a prostaglandin derivative predominantly exerting its IOP-receptor effect through the FP receptor could be combined with one or several prostaglandins exerting is IOP-reducing effect less selectively by a pronounced affinity to other of eight major prostaglandin receptors.

Preferably, a combination of IOP-reducers having different physiological actions is used in the present invention. A suitable combination would be one agent increasing the outflow of aqueous humor and one agent reducing its formation of aqueous humor. A typical combination of an IOP reducing effective amount of a prostaglandin derivative together with at least one IOP reducing agent exerting its activity through other receptors than prostaglandin receptors. Particularly useful are prostaglandins or prostaglandin derivatives capable of reducing IOP by increasing the uveoscleral outflow in combination with one or several IOP-reducing agents having another physiological action. Such prostaglandins are found among prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) analogues and derivatives such as those discussed in US Patent 4,599,353. Preferably, the prostaglandin $F_{2\alpha}$ derivatives have the carboxyl group in the alpha-chain substituted with a lower alkyl ester, such as isopropyl ester, to improve corneal penetration. Alternatively, said carboxyl group can be substituted with alcohol or ether or the similar for rendering the compound more lipophilic. Especially useful such $PGF_{2\alpha}$ derivatives have ring-formed substituent in the terminal of the omega-chain of the prostaglandin $F_{2\alpha}$ structure, such as 13,14-dihydro-17-phenyl-18,19,20-trinor-prostglandin $F_{2\alpha}$-isopropyl ester (latanoprost), 16-(meta-trifluromethyl)-phenoxy-17,18,19,20-tetranor-prostglandin $F_{2\alpha}$-isopropyl ester (travaprost) and similar compounds referred to in WO 90/02553. Ring-formed substituent is defined as an aryl group, an arylalkyl group, a heterocyclic aromatic group or a cycloalkyl group which optionally is substituted. Also useful, however less potent than the aforementioned compounds, is the $PGF_{2\alpha}$-metabolite analogue isopropyl unoprostone. Numerous other prostaglandin derivatives are described in the literature as ocular hypotensive agents or anti-glaucoma agents under denominations deviating from prostaglandin nomenclature, such as hypotensive lipids and the similar. Obviously, such compounds also will be a part of the present invention.

An IOP-reducing prostaglandin according what is stated above preferably is combined with at least one IOP reducing agent selected among cholinergic agonists (such as pilocarpine), beta-adrenegic antagonists (such as timolol), carbonic anhydrase inhibitors (such as acetazoloamide or dorzolamide) or beta-adrenergic agonists (such as dipivefrine). More suitably,

said prostaglandin is combined with one or several IOP-reducing agent capable of affecting the formation of the aqueous humor, such as a carbonic anhydrase inhibitor or a beta-adrenergic antagonist (beta-blocker). Especially preferred is a combination of a prostaglandin and a beta-adrenergic antagonist in the form of an ophthalmically acceptable composition for topical administration to the eye. Suitably the prostaglandin is a prostaglandin $F_{2\alpha}$ derivative with capacity of increasing the uveoscleral outflow, such as latanoprost, travaprost or isopropyl unoprostone. The beta-adrenergic antagonist is selected among conventional such agents including, but not limited to, acebutolol, alprenolol, atenolol, betaxolol, bisoprolol, carteolol, celiprolol, esmolol, labetalol, levobunolol, metipranolol, metoprolol, nadolol, oxprenolol, penbutolol, pindolol, propranolol, sotalol, and timolol. Especially preferable beta-adrenergic antagonist are timolol maleate, betaxolol hydrochloride, levobunolol hydrochloride and metipranolol.

The inventive therapy is conducted with regular doses of the combination, such as in the form of eye drops each having a volume of about 30 µl. Typically such a dose comprises about 0.1 to 1000 µg, preferably 0.1 to 50 µg of prostaglandin derivative and beta-adrenergic agents in the range of about 0.01 µg to 1000 µg, preferably from about 5 µg to 500 µg.

An especially preferred combination is a topical ophthalmic composition of the $PGF_{2\alpha}$ derivative latanoprost and the beta-blocker timolol. The composition further comprises conventional additives rendering it suitable for topical ophthalmic administration, such as preservatives and solubilizers. Typically, such a composition comprises from about 0.001 to 0.01%(w/v) of latanoprost and from about 0.1 to 2% (w/v) of timolol.

A greatly preferred composition to included in the combination comprises 0.5 % (5 mg/ml) timolol and 0.005 % (50 µg/ml) latanoprost together with one or several buffering agents, a preservative or solubilizer, a tonicity agent and one or several pH adjustment agents.

A specific example of composition useful in the present invention contains:

Name of Ingredients	Concentration (mg/ml)	Function
Latanoprost	50 µg	Active ingredient
Timolol maleate	6.83 mg	Active ingredient
Benzalkonium chloride	200 µg	Preservative/solubilizer
Disodium phosphate anhydrous	2.89 mg	Buffering agent
Sodium dihydrogen phosphate	6.39 mg	Buffering agent

monohydrate		
Sodium chloride	4.10 mg	Tonicity agent
10% solution Hydrochloric acid	q.s. to pH 6.0 if required	pH adjustment
10% solution Sodium Hydroxide	q.s. to pH 6.0 if required	pH adjustment
Water for injection	ad 1.00 ml	Solvent

The composition will be packaged as a sterile eye drops product in 5 ml bottles suitable for administering 30 µl drop dosages to the surface of the eye.

In the following experimental section, it has been demonstrated that a combination therapy as exemplified with the combination of latanoprost and timolol has an unexpected efficacy for patients suffering from severe glaucoma.

Exemplifying part of the description

A sub-population of 76 individuals in a population of total 854 patients enrolled into two different studies of German patients (004) and US patients (005) were identified at baseline as having some degree of abnormality to the optic nerve head together with a glaucomatous visual field defect and were treated with a fixed combination (FC) of latanoprost and timolol. Both studies were based on a randomized double-masked parallel group design. In both studies, a fixed combination (FC) of latanoprost and timolol was administered to a group of patients with optic nerve head damage and visual field loss (i.e. glaucomatous field defects) and to groups of patients without any such detected damages, but with an elevation of IOP. Patient demography and baseline characteristics in patients with and without optic nerve head damages and glaucomatous field defects are shown in Table 2.1.

The patients is the studies received one drop in the morning of a fixed combination of latanoprost (50 µg/ml) and timolol (5mg/ml) during the study duration of 26 weeks. The exact composition of fixed combination is disclosed in Table 1. At baseline, IOP assessments were made at 08:00, 10:00, and 16:00. Measurements at the same time-points were subsequently made at scheduled clinic visits at Week 2, Week 13, and Week 26. Additionally, an 08:00 measurement was also obtained at Week 6. The patients have an approximately 5 mm Hg decrease in IOP from a timolol run-in period.

Comparisons of Tables 2.2 and 2.4 related to study 004 and comparisons of Tables 2.3 and 2.5 related to study 005 demonstrates that the mean reduction in IOP (i.e. mean change from baseline) is significantly higher for patients suffering from both abnormalities of the optic nerve head and visual field defects when compared to patients having an elevated IOP but otherwise free from the mentioned complications. From these results, it is evident that the Fixed Combination (FC) of latanoprost and timolol shows an unexpected efficacy in the mentioned patient group suffering severe or advance glaucoma.

Table 1

Fixed combination of eye drops latanoprost 50 µg/ml and timolol 5mg/ml, pH=6.0

Name of Ingredients	Amount per ml
Latanoprost	50 µg
Timolol maleate (equivalent to 5 mg timolol)	6.83 mg
Polysorbate 80	0.05 mg
Benzalkonium chloride	0.10 mg
Disodium phosphate anhydrous	2.89 mg
Sodium dihydrogen phosphate monohydrate	6.39 mg
Sodium chloride	4.10 mg
Water for injection	ad 1.00 ml

Table 2. 1

Patient demography and baseline characteristics in patients with and without optic nerve head abnormalities and glaucomatous visual field defects (studies 004 and 005)

Variables	Patients with ONH damage	Patients without ONH damages
Number of patients	76	202
Gender, n(%)		
–Male	39 (51%)	95 (47%)
–Female	37 (49%)	107 (53%)
Age (years),		
Mean (SD)	64 (12)	62 (13)
Min-Max	24-83	18-86
Age class n (%)		
<60 years	25 (33%)	78 (39%)
60-70 years	27 (36%)	67 (33%)
≥70 years	24 (32%)	57 (28%)
Ethnic origin, n (%)		
– Caucasian	63 (83%)	166 (82%)
– Black	10 (13%)	28 (14%)
– Asian	1 (1%)	0
– Oriental	0	1 (<1%)
– Hispanic	1 (1%)	6 (3%)
– American Indian	0	0
– Other	1 (1%)	1 (<1%)
Diagnosis of study eye(s), n (%)		
–POAG	66 (87%)	134 (66%)
–Exfoliation Glaucoma	2 (3%)	2 (1%)
–Pigmentary Glaucoma	2 (3%)	5 (2%)
–Ocular Hypertension	6 (8%)	57 (28%)
–Mixed diagnosis	0	4 (2%)
Eye color study eye(s), n* (%)		
– Homogeneously blue, gray or green	22 (29%)	59 (29%)
– Homogeneously brown	21 (28%)	69 (34%)
– Blue-brown/gray-brown	24 (32%)	57 (28%)
– Green-brown	8 (11%)	12 (6%)
– Yellow-brown	1 (1%)	5 (2%)

Table 2.1 Patient demography and baseline characteristics in patients with and without optic nerve head abnormalities and glaucomatous visual field defects (studies 004 and 005): continued

Variables	Patients with ONH damage	Patients with ONH damage
Number of patients	**76**	**202**
Duration of therapy, n* (%)		
<6 months	11 (13%)	30 (15%)
6-36 months	9 (12%)	53 (26%)
36-100 months	31 (41%)	59 (29%)
>100 months	25 (33%)	60 (30%)
Glaucoma meds at entry, n (%)		
> one	41 (54%)	90 (45%)
one or none	35 (46%)	112 (55%)
Family history of OH/glaucoma, n* (%)	21 (28%)	62 (31%)

Table 2.2 Mean change in IOP (mmHg) from baseline and differences between treatments at each time point during the study treatment period, study 004 (patients with abnormalities of ONH and visual field defects)

Time	Visit	FC 42 patients	
		IOP (mmHg)	Mean baseline change in IOP (mmHg)
	Baseline	22.5	
08:00	Week 2	18.8	-3.7
	Week 6	18.8	-3.7
	Week 13	19.2	-3.3
	Week 26	19.1	-3.4
10:00	Baseline	22. 2	
	Week 2	18.4	-3.9
	Week 13	20.0	-2.2
	Week 26	18.7	-3.5
16:00	Baseline	21.8	
	Week 2	18.4	-3.4
	Week 13	18.4	-3.4
	Week 26	18.5	-3.3

Table 2.3 **Mean change in IOP (mmHg) from baseline and differences between treatments at each time point during the study treatment period, study 005 (patients with abnormalities of ONH and visual field defects)**

		FC 34 patients	
Time	**Visit**	**IOP mmHg**	**Mean baseline change in IOP (mmHg)**
08:00	Baseline	24.6	
	Week 2	20.0	-4.6
	Week 6	19.9	-4.7
	Week13	20.1	-4.4
	Week26	20.7	-3.9
10:00	Baseline	22.8	
	Week 2	20.0	-2.8
	Week 13	19.5	-3.3
	Week 26	19.9	-2.9
16:00	Baseline	22.9	
	Week 2	19.1	-3.8
	Week 13	18.2	-4.8
	Week 26	19.6	-3.3

Table 2.4

Mean change in IOP (mmHg) from baseline and differences between treatments at each time point during the study treatment period, study 004 (patients without abnormalities of ONH and visual field defects)

Time	Visit	FC 98 patients	
		IOP mmHg	Mean baseline change in IOP mmHg
08:00	Baseline	22.2	
	Week 2	19.8	-2.4
	Week 6	19.4	-2.9
	Week 13	19.5	-2.7
	Week 26	19.5	-2.7
10:00	Baseline	21.4	
	Week 2	19.0	-2.4
	Week 13	18.9	-2.5
	Week 26	19.3	-2.1
16:00	Baseline	20.6	
	Week 2	18.3	-2.3
	Week 13	18.2	-2.4
	Week 26	18.3	-2.3

Table 2.5

Mean change in IOP (mmHg) from baseline and differences between treatments at each time point during the study treatment period, study 005 (patients without abnormalities of ONH and visual field defects)

Time	Visit	FC 104 patients	
		IOP mmHg	Mean change in IOP from baseline mmHg
08:00	Baseline	24.1	
	Week 2	20.9	-3.2
	Week 6	20.5	-3.6
	Week 13	20.7	-3.4
	Week 26	20.6	-3.5
10:00	Baseline	22.8	
	Week 2	19.9	-3.0
	Week 13	19.7	-3.2
	Week 26	20.0	-2.8
16:00	Baseline	22.0	
	Week 2	18.8	-3.2
	Week 13	18.7	-3.2
	Week 26	19.0	-2.8